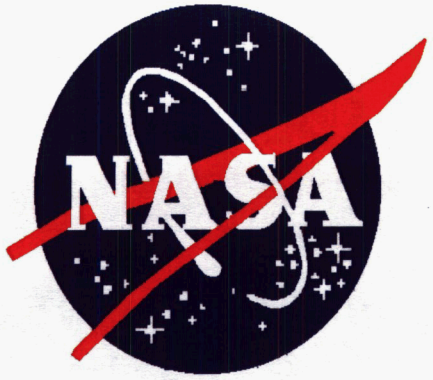


Mission Operations Insights

February 17, 2006

Dave Littmann / Lou Parkinson
NASA / GSFC

Agenda

- 10 min Mission Operations Overview
- 20 min Polar Operational Environmental Satellites (POES)
- 20 min SWIFT
- 10 min Q & A

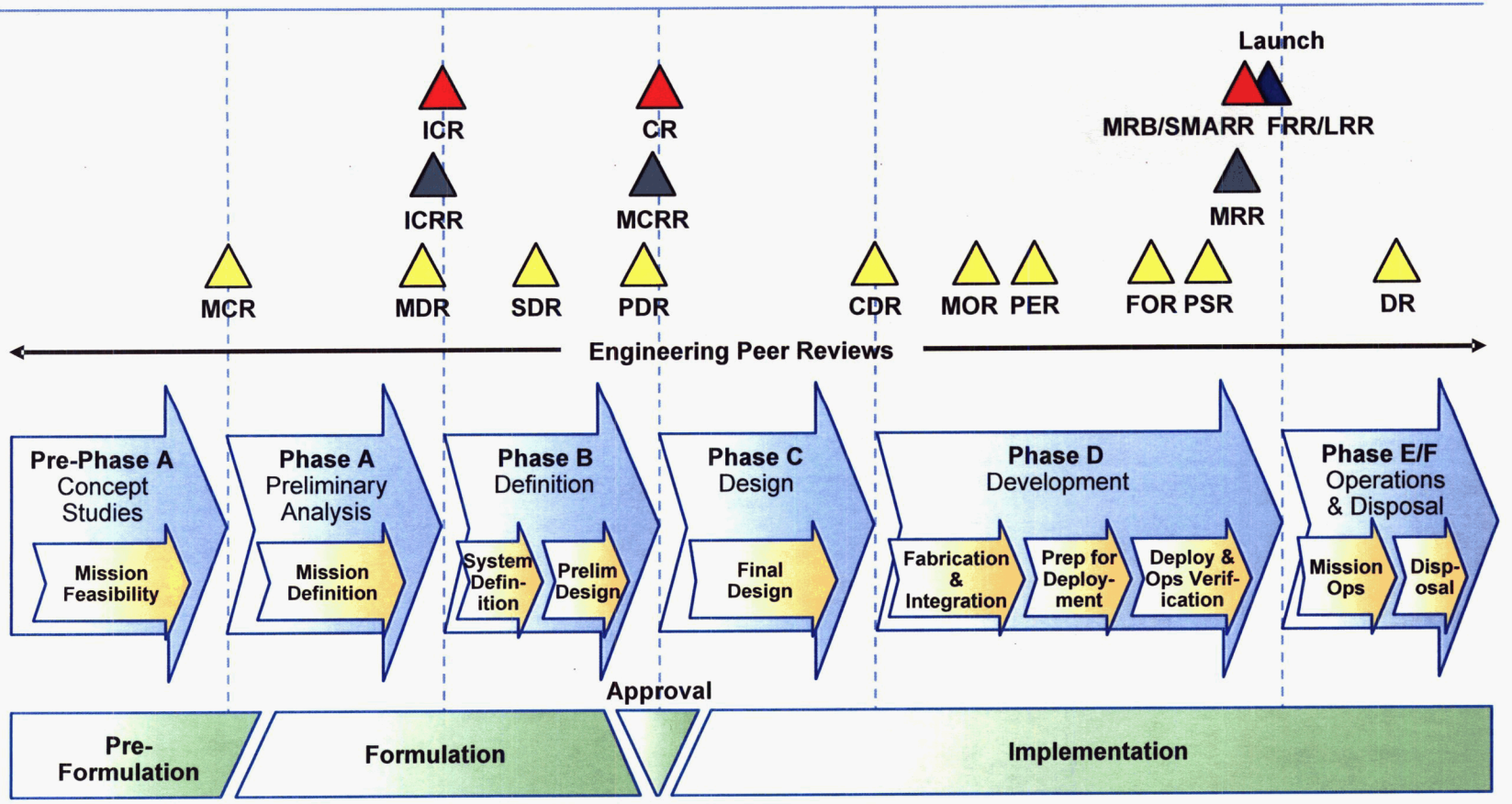
Mission Operations Overview

Fundamental 24/7 Responsibility to

"**Fly the Mission**"

Spacecraft Launch Vehicle Ground System
On-Orbit Operations Mission Data Products
Anomaly Detection/Response

Mission Life Cycle



LEGEND

- HQ Reviews
- IIRT Reviews
- GPMC Gateway Reviews
- KSC Pre-Launch Readiness Review

CDR - Critical Design Review
CR - Confirmation Review
DR - Disposal Review
FOR - Flight Operation Review
FRR - Flight Readiness Review
ICR - Initial Confirmation Review
ICRR - Initial Confirmation Readiness Review
LRR - Launch Readiness Review
MCR - Mission Concept Review
MCRR - Mission Confirmation Readiness Review

MDR - Mission Definition Review
MOR - Mission Operations Review
MRB - Mission Readiness Briefing
MRR - Mission Readiness Review
PDR - Preliminary Design Review
PER - Pre-Environment Review
PSR - Pre-Ship Review
SDR - System Definition Review
SMARR - Safety & Mission Assurance Readiness Review

Mission Operations Overview

Formulation

(beginnings)

mission concept and objectives

↓

primary driving mission / science requirements

↓

orbit, payload requirements
instruments, data types, volume, latency
communication frequencies, assets,
mission data processing and products
external interfaces, reporting
security, availability, duration, decommission
facilities, staffing, budget

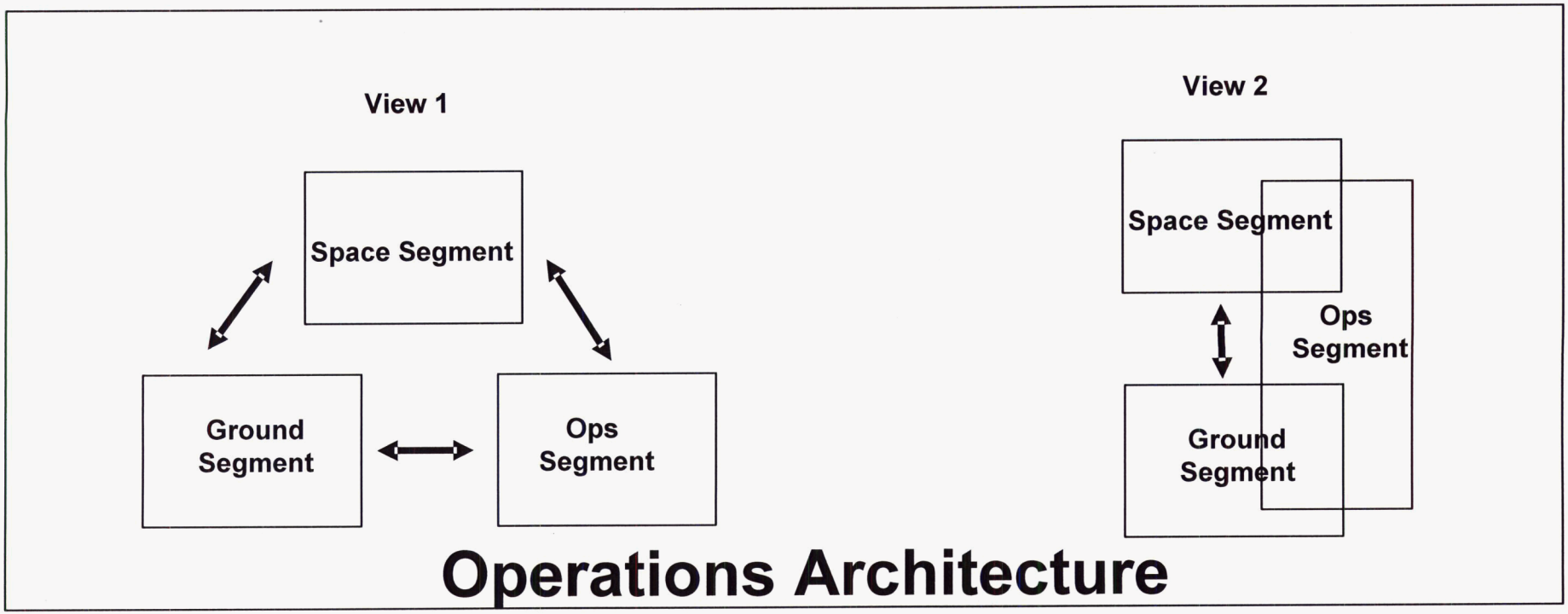
↓

Operations Concept

Mission Operations Overview

Development

Make Operations Concept Functional



Operations Architecture

(framework to visualize and identify the specific environment and activities for achieving the mission goals and objectives)

Mission Operations Overview

Execution / Readiness

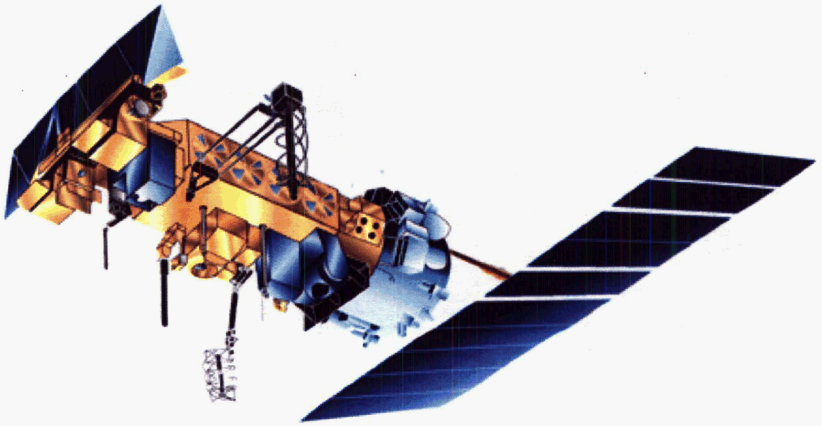
"build" and integration of architecture
verification / validation of components and interfaces
operational planning with spacecraft and instrument teams
end to end functional testing with all external interfaces/assets
launch, activation, on-orbit verification, orbit by orbit
training, simulation, contingency response
staffing, facilities, launch hold criteria
(the bathtub, kitchen sink, anything else that will matter !)

Test as you fly, fly as you test

Mission Operation Readiness Review

(and many others!)

!!! Mission Operations GO for Launch !!!



Polar Operational Environmental Satellites (POES)

Mission Description (POES)

- Joint program between NASA and NOAA
  - NASA, funded by NOAA, procures and launches satellites
  - NOAA performs satellite operations and science data processing/distribution
- Continuous operational program since 1970's
  - Launch schedules determined based on health of on-orbit constellation
- Satellites collect global measurements of the earth's surface and atmosphere
  - Two operational satellites cover entire planet at least 4 times a day
- Primarily used for operational meteorology and environmental studies
  - Science data is continuously broadcast worldwide
  - Science data stored on-board and played back over NOAA ground stations
- Search and Rescue System also provided
  - Detection and relay of distress signals
  - Estimated to have saved over 17,000 lives

Mission Description (POES)

- Collect and disseminate worldwide meteorological and environmental data
  - Provide day and night information (AVHRR)
    - Cloud cover distribution and cloud type
    - Cloud top temperature
    - Moisture patterns and ice/snow melt
  - Provide vertical temperature and moisture profiles of atmosphere (HIRS, AMSU, MHS)
  - Measure global ozone distribution and solar UV radiation (SBUV)
  - Measure proton, electron, and charged particle density to provide solar storm warnings (SEM)
  - Collect environmental data (DCS)
    - Stationary platforms in remote locations
    - Free floating platforms on buoys, balloons, migratory animals
- Provide Search and Rescue capabilities (SARR, SARP)
  - Detection and relay of distress signals
  - Has saved thousands of lives around the world

NOAA Polar Constellation

- Operational system consists of two satellites
  - 2:00 PM Ascending Orbit - NOAA-16 (launched 9/21/00)
  - 10:00 AM Descending Orbit - NOAA-17 (launched 6/24/02)
- Older satellites provide some useful data
  - NOAA-15 (launched 5/13/98)
  - NOAA-14 (launched 12/30/94)
  - NOAA-12 (launched 5/14/91)
- NOAA-N Launch – May 20, 2005
  - Replaces NOAA-16
  - 2:00 PM ascending orbit

NOAA Polar Constellation

- Mission Design Life: 2 years

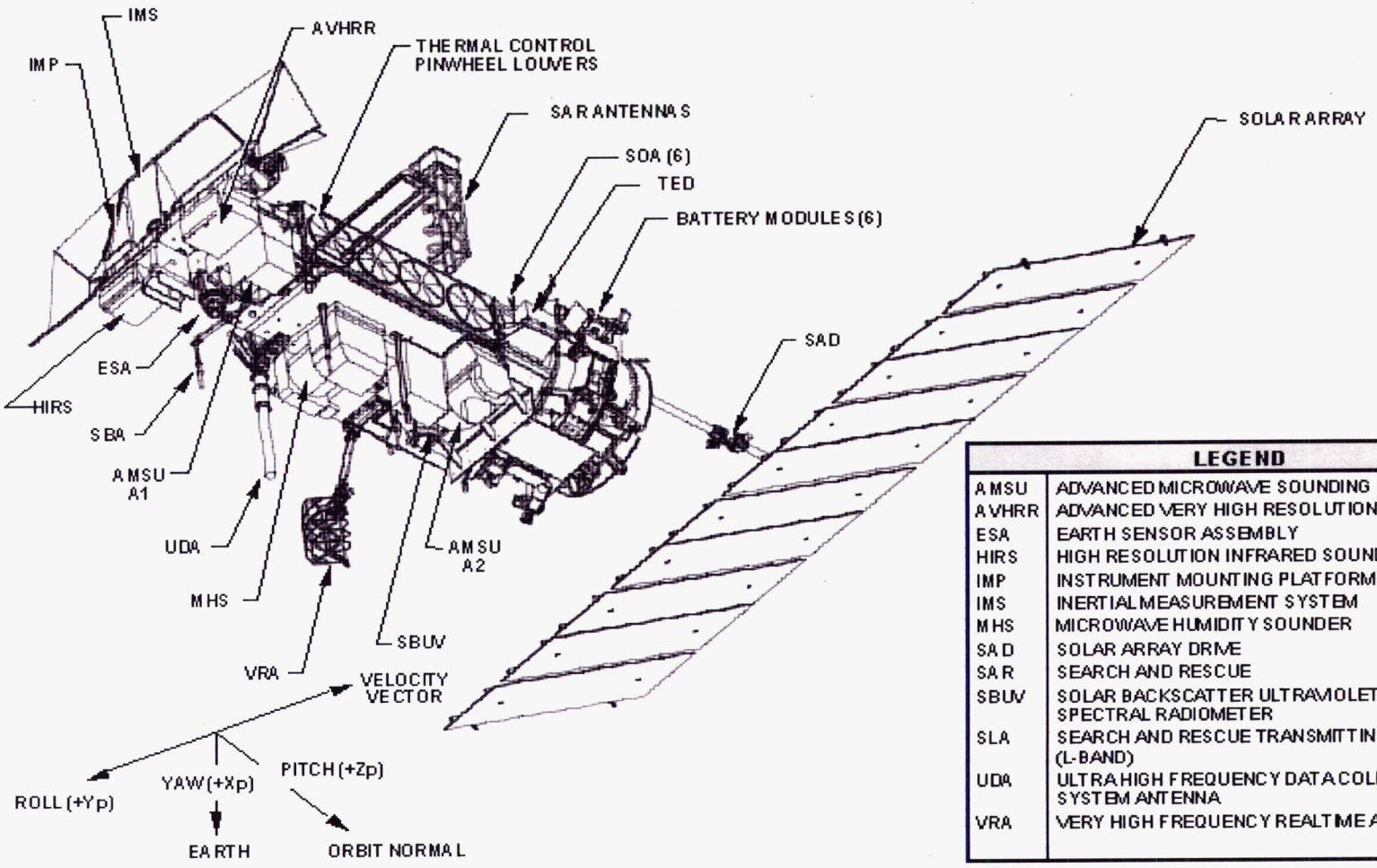
- Launch
  - Date: 20 May 2005
  - Time: 10:22 GMT (3:22 PDT, 6:22 EDT)
  - Window: 10 minutes
  - Site: Vandenberg AFB (SLC-2)
  - Launch Vehicle: Delta II
  - Liftoff Mass: 3150 lbs

- Orbit
  - Equatorial Crossing Time: 2:00 pm local solar time (north bound)
  - Altitude: 870 km (470 nmi)
  - Inclination: 98.730 degrees (sun synchronous)
  - Orbital Period: 102 minutes

NOAA-N Instrument Payload

AVHRR	Advanced Very High Resolution Radiometer – ITT
HIRS/4	High Resolution Infrared Sounder - ITT
AMSU-A	Advanced Microwave Sounding Unit – A1 and A2 - Northrop Grumman (formerly Aerojet)
MHS	Microwave Humidity Sounder - donated by EUMETSAT
SEM/3	Space Environmental Monitor - ATC (formerly GE/Panametrics)
SBUV/2	Solar Backscattered Ultraviolet Radiometer - Ball
SARR	Search and Rescue Repeater - donated by Canada
SARP/2	Search and Rescue Processor - donated by France
DCS/2	Data Collection System – donated by France

NOAA-N Spacecraft

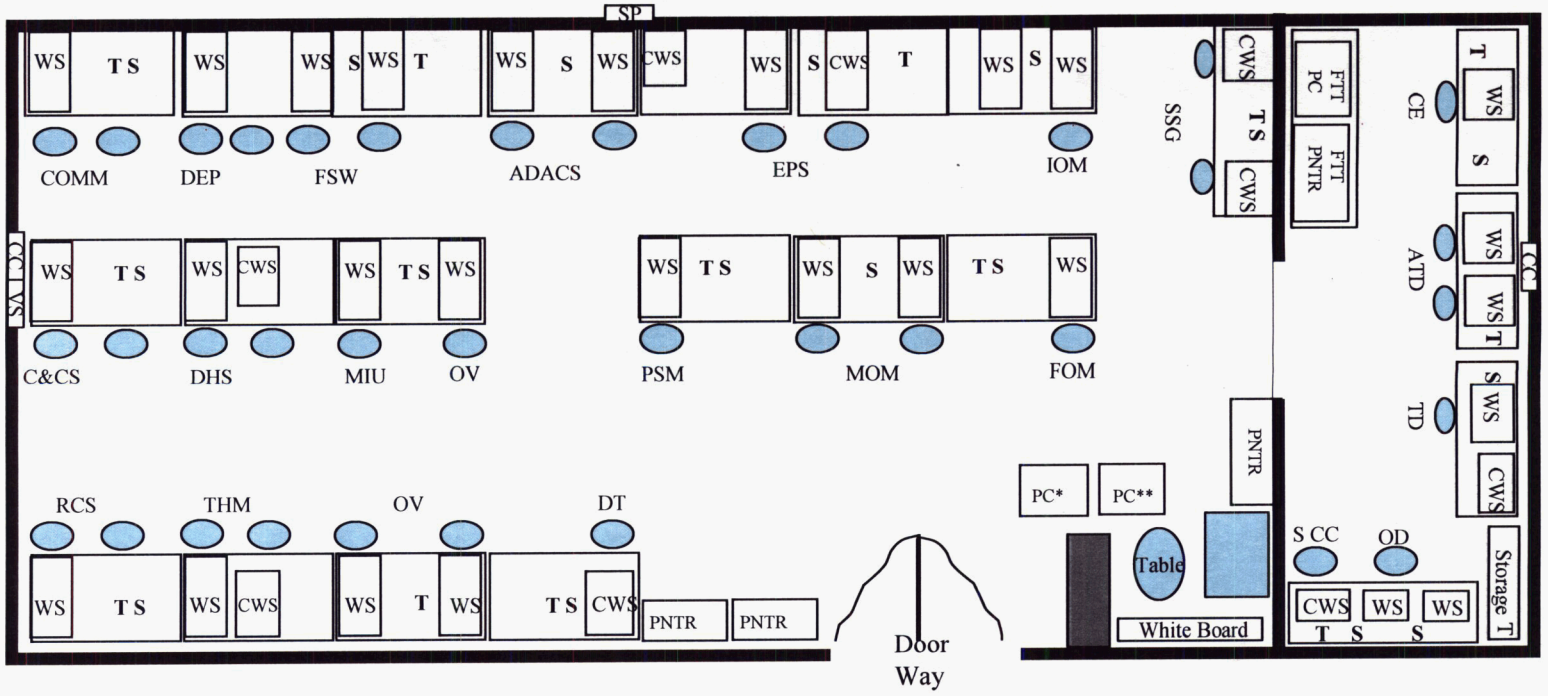


LEGEND	
AMSU	ADVANCED MICROWAVE SOUNDING UNIT
AVHRR	ADVANCED VERY HIGH RESOLUTION RADIOMETER
ESA	EARTH SENSOR ASSEMBLY
HIRS	HIGH RESOLUTION INFRARED SOUNDER
IMP	INSTRUMENT MOUNTING PLATFORM
IMS	INERTIAL MEASUREMENT SYSTEM
MHS	MICROWAVE HUMIDITY SOUNDER
SAD	SOLAR ARRAY DRIVE
SAR	SEARCH AND RESCUE
SBUV	SOLAR BACKSCATTER ULTRAVIOLET SOUNDING SPECTRAL RADIOMETER
SLA	SEARCH AND RESCUE TRANSMITTING ANTENNA (L-BAND)
UDA	ULTRA HIGH FREQUENCY DATA COLLECTION SYSTEM ANTENNA
VRA	VERY HIGH FREQUENCY REALTIME ANTENNA

NOAA-N Operations Readiness

- Mission Operations Facilities / Layout
- Operations Interface Definition and Verification
- Ground System Verification
- Database Validation
- Contingency Operations Procedures
- Flight Time Table
- On-Orbit Verification
- Spacecraft Stored Command Table
- Ephemeris
- Training
- Simulations
- Routine Mission Staffing / Support

NOAA-N Launch Control Room



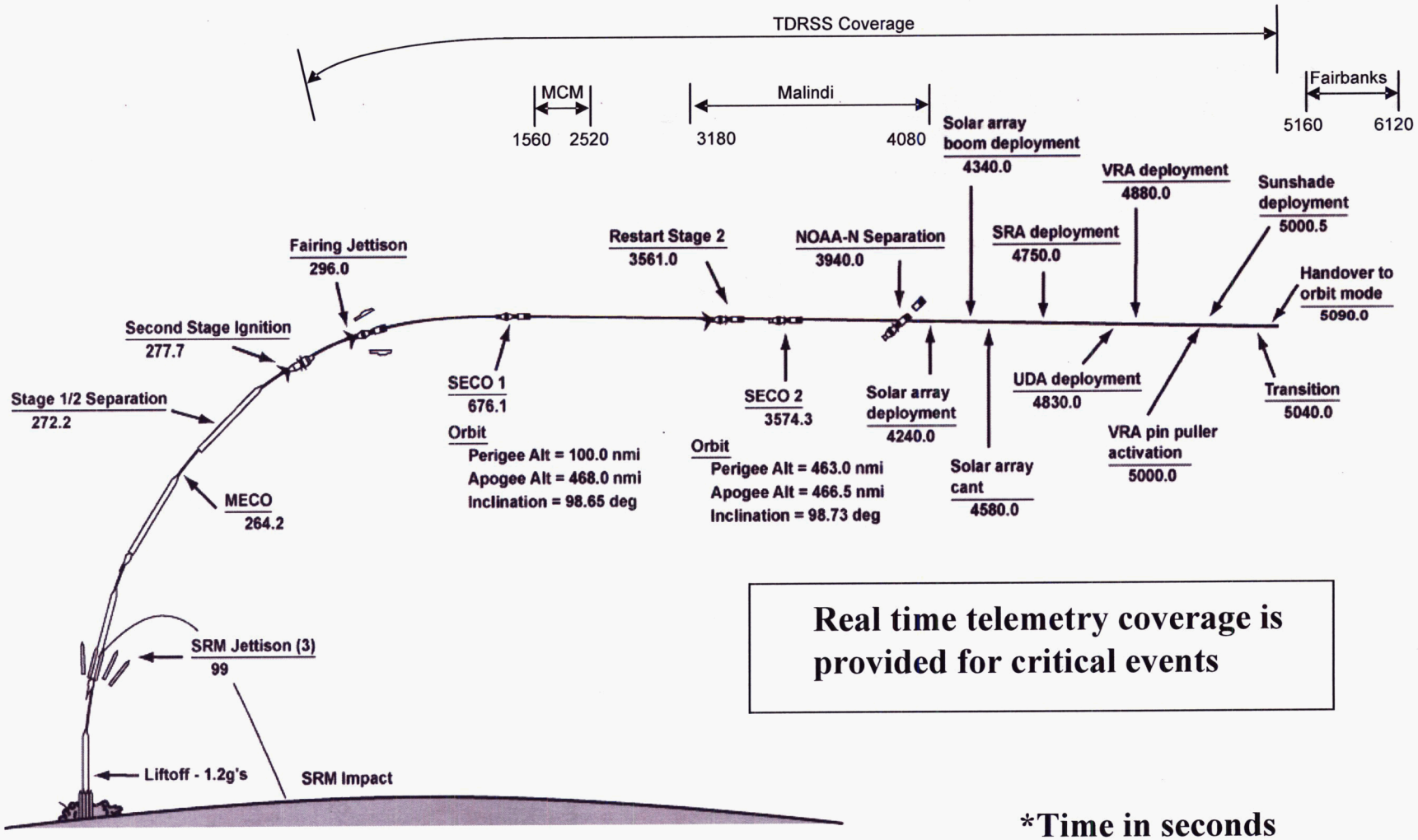
CC	Countdown Clock
CE	Command Engineer
DT	Data Tech
PC*	McMurdo Remote Control PC
PC**	Graf Track PC

S	SCAMA Phones
SCC	Spacecraft Controller
SSG	Suitland SOCC Ground
SP	Speaker
T	Telephone
VS	Video Screen

Chair

Cable Cabinet

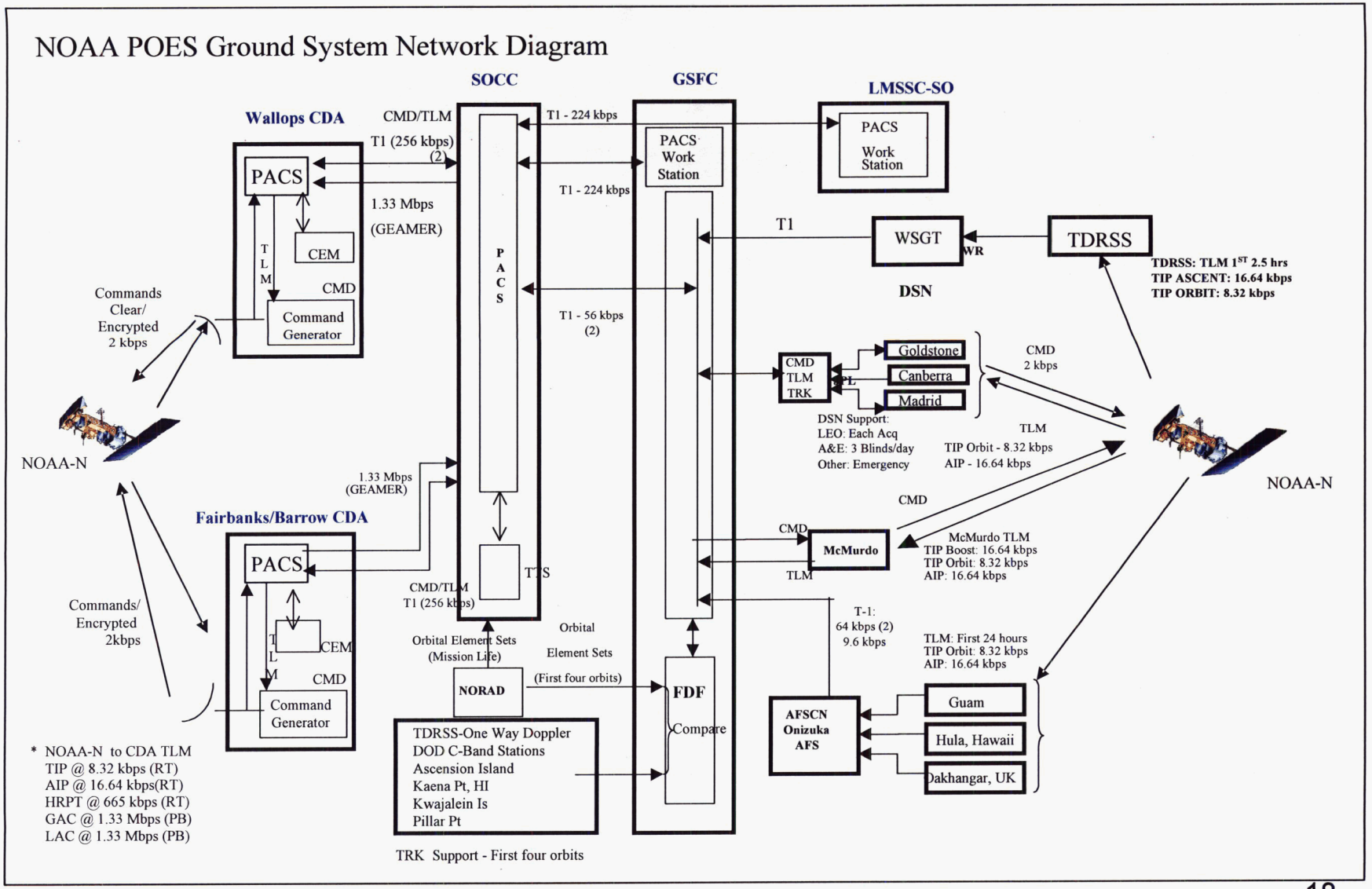
NOAA-N Ascent Profile



Real time telemetry coverage is provided for critical events

***Time in seconds**

NOAA-N Operational Architecture



POES Operations Readiness

- Database Validation
  - Use of limits, cal curves, x-y plots and reports, to validate
  - Use of playback data from spacecraft testing to verify telemetry databases
  - Use spacecraft simulator to verify command and command procedure databases
  - Joint activity with spacecraft and instrument vendors
  - All changes under configuration control, complete prior to training simulations

- Contingency Procedures
  - Anomalies that are serious enough to constitute an immediate threat to the health and safety of the spacecraft or instruments need contingency procedures (COPs)
  - Time is of the essence
  - Pre-planned response to a serious contingency (usually flagged in telemetry) which may cause an immediate threat to the spacecraft, subsystem, or instrument
  - Eliminate or mitigate threat prior to detailed engineering assessment

POES Operations Readiness

- On-Orbit Verification
  - Determine whether NOAA-N meets specifications
  - Characterize performance of spacecraft and instruments
  - Detailed plan developed with spacecraft and instrument vendors
  - Critical tests supported by spacecraft and instrumented vendors
  - Conducted from NOAA Satellite Operations Control Center
  - Directed by NASA Mission Operations Manager

- Flight Time Table
  - The POES Mission Operations bible early in mission
  - Provides a per pass listing of each spacecraft contact and commanding
    - Stored Command Table, scheduled, or manual commands identified
    - Contingency information
    - On-orbit verification (OV) test information

POES Operations Readiness

NOAA-M Flight Time Table (FTT)

Rev 1 Fairbanks

Contact Information

COMMAND SITE: YES

SITE SOURCE: I

SITE SOURCE ID: L24ACOMB.TXT

CONDITIONAL CMD Y PASS NOTES Y

OV TEST Y PASS SUMMARY

JDay 175 AOS 19:51:50 FCT 19:52:50 Max El 42.3 LCT 20:05:20 LOS 20:07:00

Nominal Commanding

SCHEDULE ID: SCH17_174.CMD;17

SCT ID: 17_VALSCT_174.RPT;1

Time	Source	Action	Description	Subsystems		Done?
19:52:55	SCHED	CMD NOOOP OBP=C	NO OPERATION	CCS	FSW	
19:53:00	SCHED	CMD NOOOP OBP=N	NO OPERATION	CCS	FSW	
19:53:10	SCHED	CMD DAUR1 OBP=C	DAU 1 RESET	CCS	FSW	
19:53:20	SCHED	CMD DAUR2 OBP=C	DAU 2 RESET	CCS	FSW	
19:54:00	MAN	CMD TIPMCORB OBP= C	DWELLS ON CHANNEL 0153	DHS	CCS	
19:54:30	CP	CP START = CDHTRN	RSS HEATERS C AND D ON	THERM		
19:56:00	CP	CP START = INHONA	AVHR/HIRS COOLER HEATERS & AVHRR	AVHRR	HIRS	
19:56:55	SCT	XSULS5A 8000	LAC STOP DTR 5A	DHS		
19:57:00	SCT	XSUSP5A 82C0	STIP PLAY DTR 5A	DHS		
19:57:10	CP	CP START = ENCTIMEN	ENABLE ENCRYPTION TIMERS AND	CCS	FSW	
19:58:00	MAN	CMD FMBVE OBP= N	SETS FLAG TO ENABLE MONITORING	EPS	FSW	
19:59:00	MAN	CMD FMBVE OBP= C	SETS FLAG TO ENABLE MONITORING	EPS	FSW	
20:01:05	SCT	XSULS5A 8000	LAC STOP DTR 5A	DHS		
20:01:10	SCT	XSUFP5A 8C40	FWD PLAY DTR 5A	DHS		
20:03:05	SCT	XSULS5A 8000	LAC STOP DTR 5A	DHS		
20:03:30	SCT	XSUSP5A 82C0	STIP PLAY DTR 5A	DHS		

POES Operations Readiness

- Spacecraft Stored Command Table
  - On-board time queued command list
  - Uplinked from ground every 48-72 hours
  - Autonomous execution independent of ground contact

- Ephemeris
  - Representation of Earth location wrt spacecraft orbit / attitude
  - Consistency and continuity necessary for communication contact
  - Updates to spacecraft at regular intervals every 48-72 hours

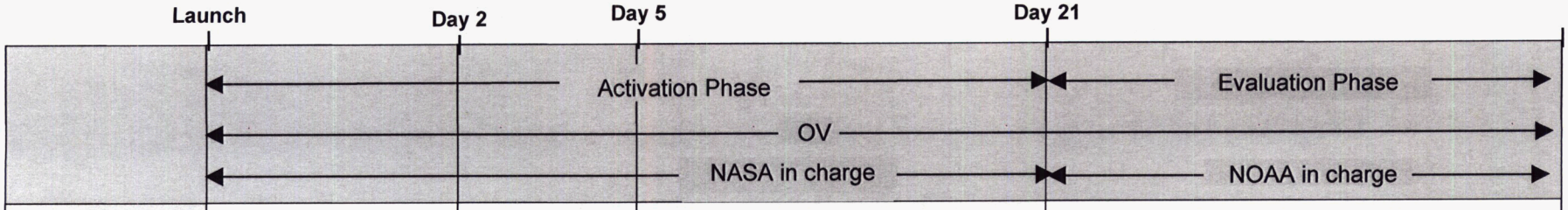
POES Operations Readiness

- Training and Simulations
  - Classroom
    - Focused specific to Flight Operations Team (FOT) positions
  - Hands-On
    - Focused specific to FOT position
    - Monitor Real-time spacecraft or playback data
    - Playback or simulation of spacecraft anomaly
  - Launch Control Room (LCR) Orientation
    - Expose personnel to voice loops/protocol, ops docs, ground system
  - Instrument Simulation
    - Emulate instrument activations, review instrument telemetry from operational spacecraft
  - Network Simulations
    - Validate external network interfaces, voice loops, and data flows are functional
  - Dress Rehearsals
    - Expose personnel to nominal and anomalous spacecraft performance

NOAA-N Launch Readiness

- Location of all NOAA-N key personnel defined for launch day
  - Managers
  - Spacecraft Engineers
  - Flight Operations Team
- Launch commit criteria established for
  - Spacecraft
  - Booster
  - Ground system
- NOAA SOCC h/w, s/w, facilities are functional and ready to support
- NOAA SOCC procedures, databases, and software proven through simulations and tests with NOAA-N spacecraft
- All COntingency Procedures (COPs) are reviewed and simulated
- NOAA-N Flight Operations Team (FOT) is ready and trained to support NOAA-N launch, activation, and evaluation
- NOAA SOCC ready to assume operational responsibility of NOAA-N

POES NOAA-N Ops Timeline



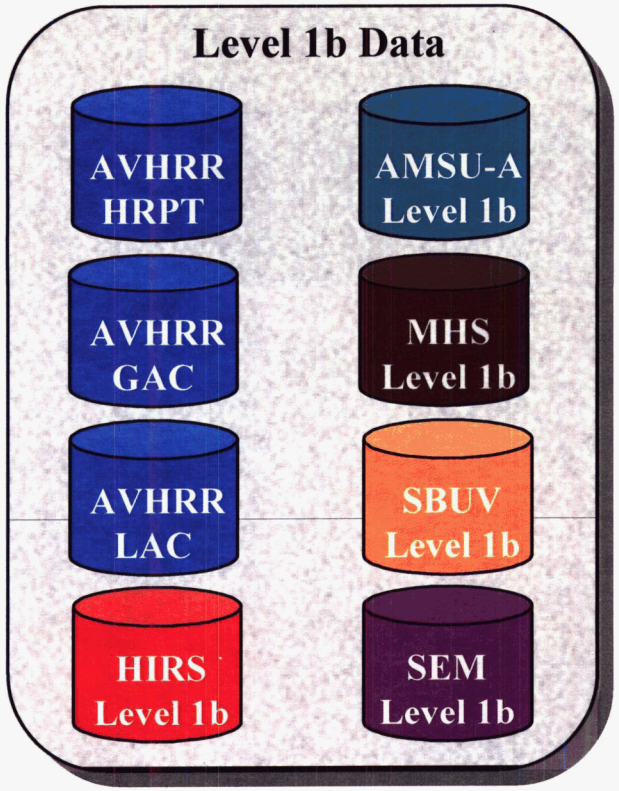
LMSSC	24 h/d Prime - 11 positions - ATD, EPS, THM, ADACS, COMM, DHS, FSW, CCS, RCE, MIU, DEPLOY	10 hr day shift (Till T+ 100 hrs) 9 positions - ATD, EPS, THM, ADACS, COMM, DHS, FSW, CCS, MIU	On-call at Sunnyvale	
NASA	24 h/d Prime - 4 positions - FOM, MOM, PSM, IOM Backup - 10 positions - ATD, EPS, THM, ADACS, COMM, DHS, FSW, CCS, RCE, DEPLOY	Three 8-hr shifts 4 positions - FOM, MOM, PSM, IOM Two 8-hr shifts 8 positions - ATD, EPS, THM, ADACS, COMM, DH, FLT S/W, C&CS	Three 8-hr shifts 6 positions - FOM, MOM, IOM, ATD EPS, ADACS	The OV manager coordinates instrument Support during instrument OV testing.
NOAA	Mission Ops – 24 h/d 7 positions - TD, OD, S/C CTL, Suitland SOCC Ground 1 & 2, CMD ENG, Data Tech	Mission Ops – 24 h/d 5 positions - TD, OD, S/C CTL, Data Tech, CMD ENG	Mission Ops – 24 h/d 5 positions - TD, OD, S/C CTL, Data Tech, CMD ENG	Nominal NOAA staffing

NOAA Polar Daily Operations

- Spacecraft continuously "managed" to accomplish mission, providing data to the CDA site for relay and subsequent ground processing
- Spacecraft state checked each contact to ensure health and safety.
- On-Board ephemeris and stored command table actively planned and updated for autonomous execution while out of ground contact.
- On-Board record/playback of mission data prime function (9 instruments, many antennae at various frequencies, several data types, 5 onboard recorders).
- NOAA Engineers respond to any issues which may threaten or impact mission performance (space, ground, etc).
- NASA provides support as needed to investigate anomalies, to include spacecraft vendor as needed. Spacecraft anomalies formally tracked and investigated

NOAA DATA PRODUCTS

Color Coded to Instrument

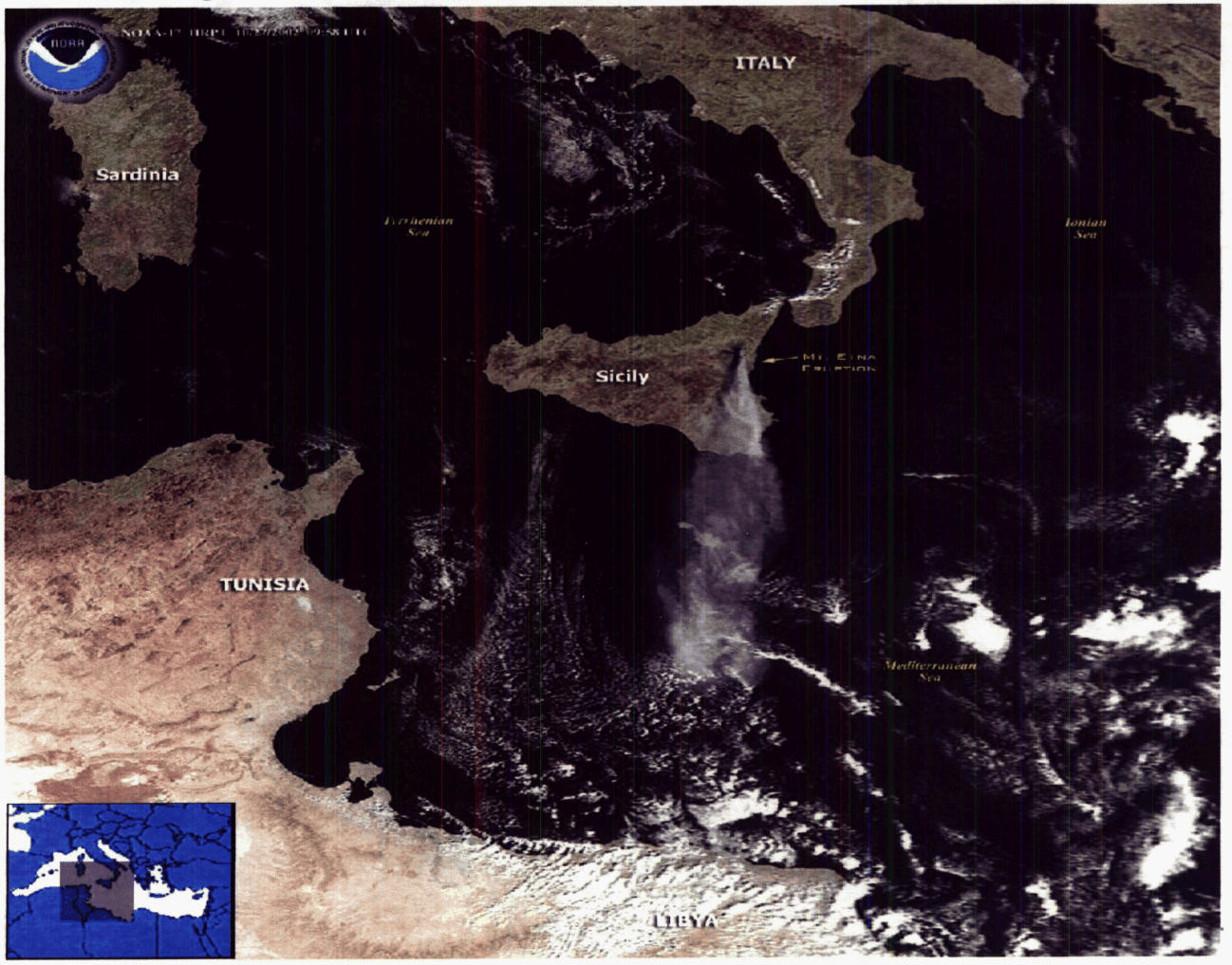


- Significant Event Imagery
- Atmospheric Temperature
- Atmospheric Moisture
- Snow/Ice Coverage
- Precipitation
- Aerosols
- Ozone
- CoastWatch
- Winds
- Solar Environment Monitoring
- Radiation Budget
- Vegetation Index
- Sea Ice Monitoring
- Cloud Imagery
- SST

NOAA DATA PRODUCTS

Volcanic Ash Detection

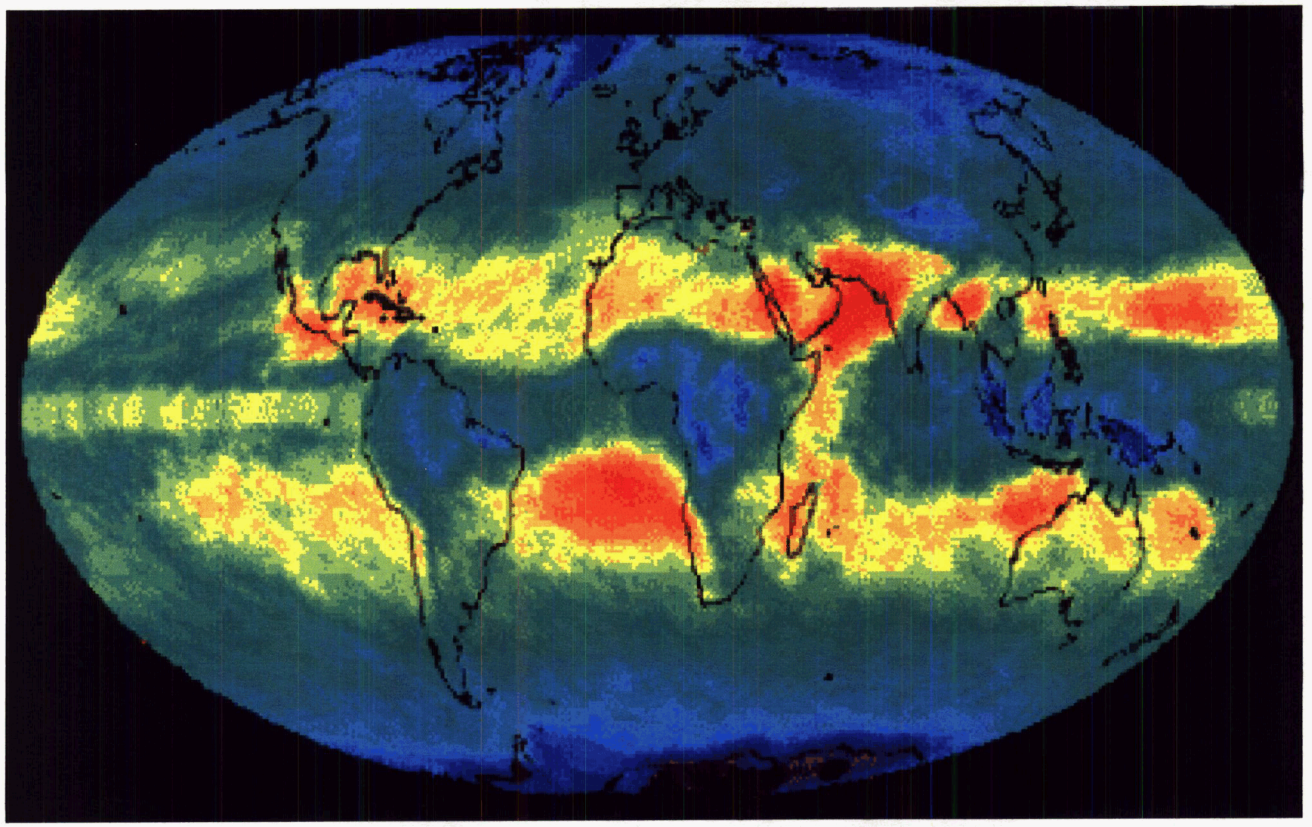
The detection and tracking of volcanic ash plumes, such as this image from Mt. Etna, are particularly useful to the air traffic industry since volcanic ash can cause damage to jet engines which could result in engine shutdowns.



NOAA DATA PRODUCTS

Radiation Budget

Radiation budget products describe the distribution of the incoming and outgoing radiation at the top of the atmosphere and are used to study global climate change.




NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Swift
CATCHING GAMMA-RAY BURSTS ON THE FLY

SWIFT

Scientific Motivation for Swift:
Gamma Ray Bursts…

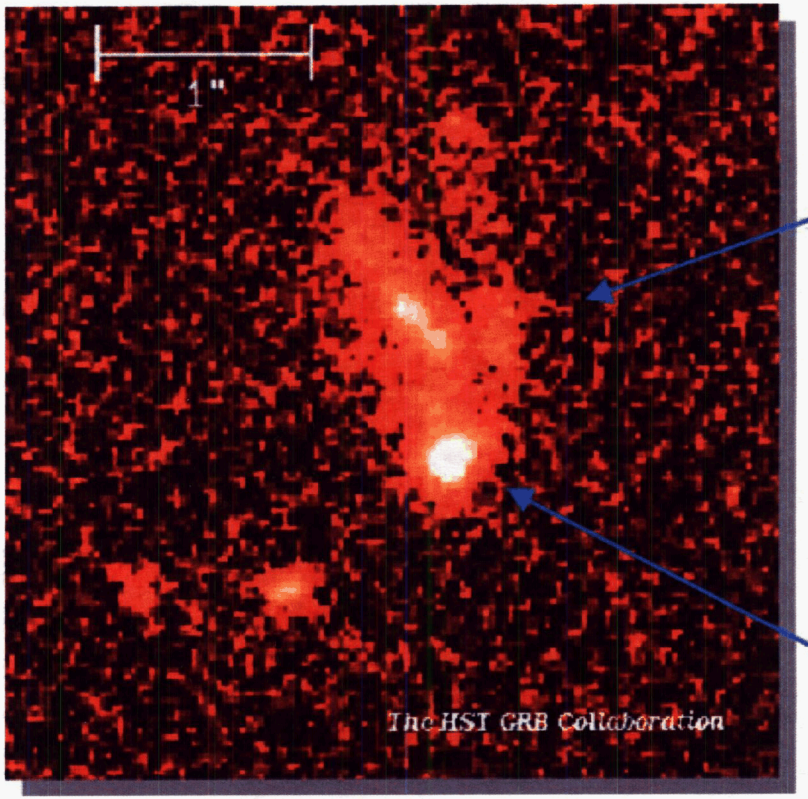
Most Powerful Explosions in Universe

Birth Sites of Black Holes

Ultra-relativistic
Outflows

Relation to
Supernovae

Probes of the
Early Universe

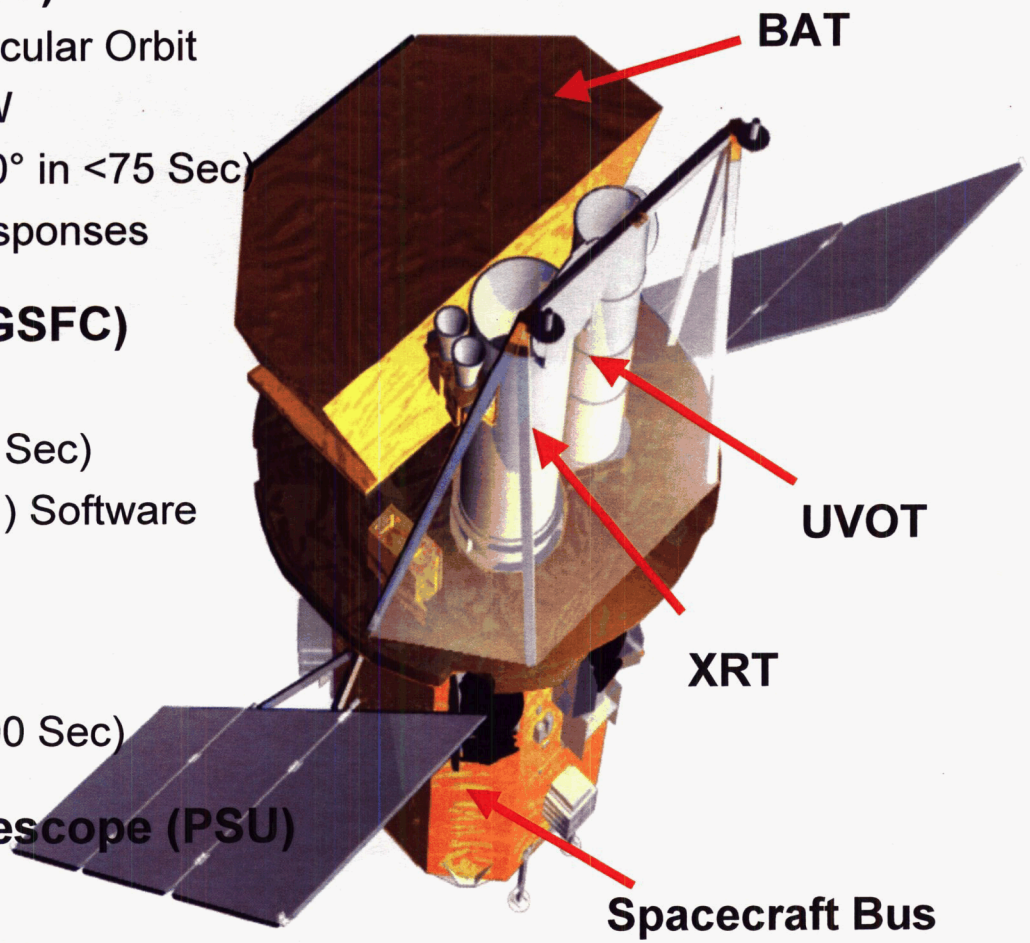


Major Mission Goals

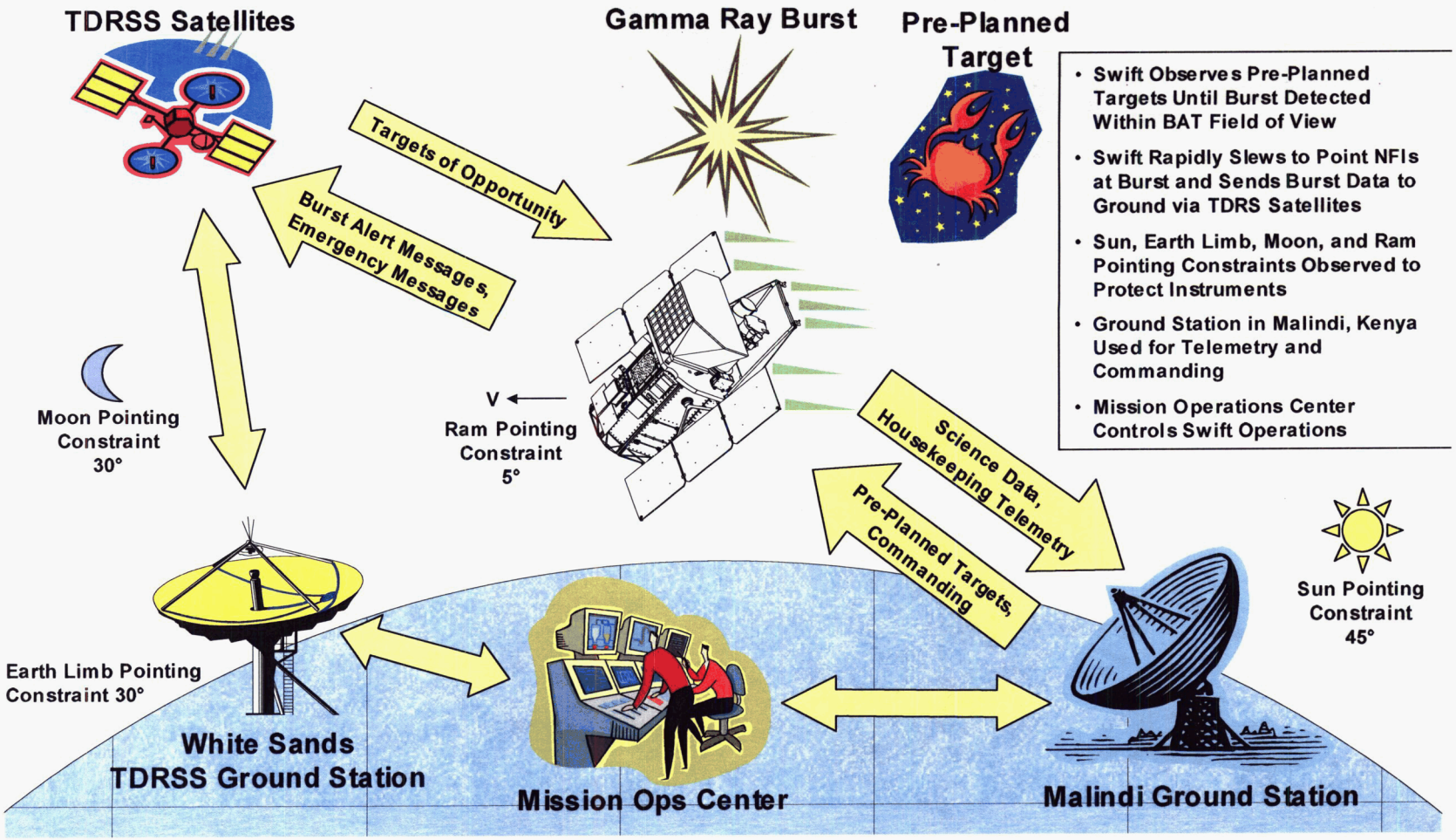
- Autonomously Detect and Observe Gamma Ray Bursts (GRBs)
- Autonomously Slew to GRBs (No Ground Intervention)
- Forward GRB Data (e.g., Position, Basic Characteristics) to Ground System Within 20 Seconds
- Quickly And Autonomously Distribute Newly Detected GRB Information To Global Astronomy Science Community
- Perform Afterglow Observations in X-Ray and Ultraviolet Spectrum
- Perform Hard-X-Ray Survey (Pre-Planned Targets)
- Perform Follow-On Observations (Pre-Planned Targets)

Swift Observatory

- **Spacecraft Bus (Spectrum Astro)**
  - 20.6° Inclination, 600km Near Circular Orbit
  - 1500 kg, Average Power ~1000W
  - Autonomous Repointing (Fast: 50° in <75 Sec)
  - Autonomous Onboard Safing Responses
- **BAT – Burst Alert Telescope (GSFC)**
  - CdZnTe Detector Array
  - Arcminute GRB Positions (w/i 20 Sec)
  - Observation Figure of Merit (FoM) Software
- **XRT – X-Ray Telescope (PSU)**
  - CCD Spectroscopy
  - Arcsecond GRB Positions (w/i 100 Sec)
- **UVOT – UltraViolet Optical Telescope (PSU)**
  - Grism Spectroscopy
  - Sub-arcsecond Imaging for Finding Chart (w/i 270 Sec)

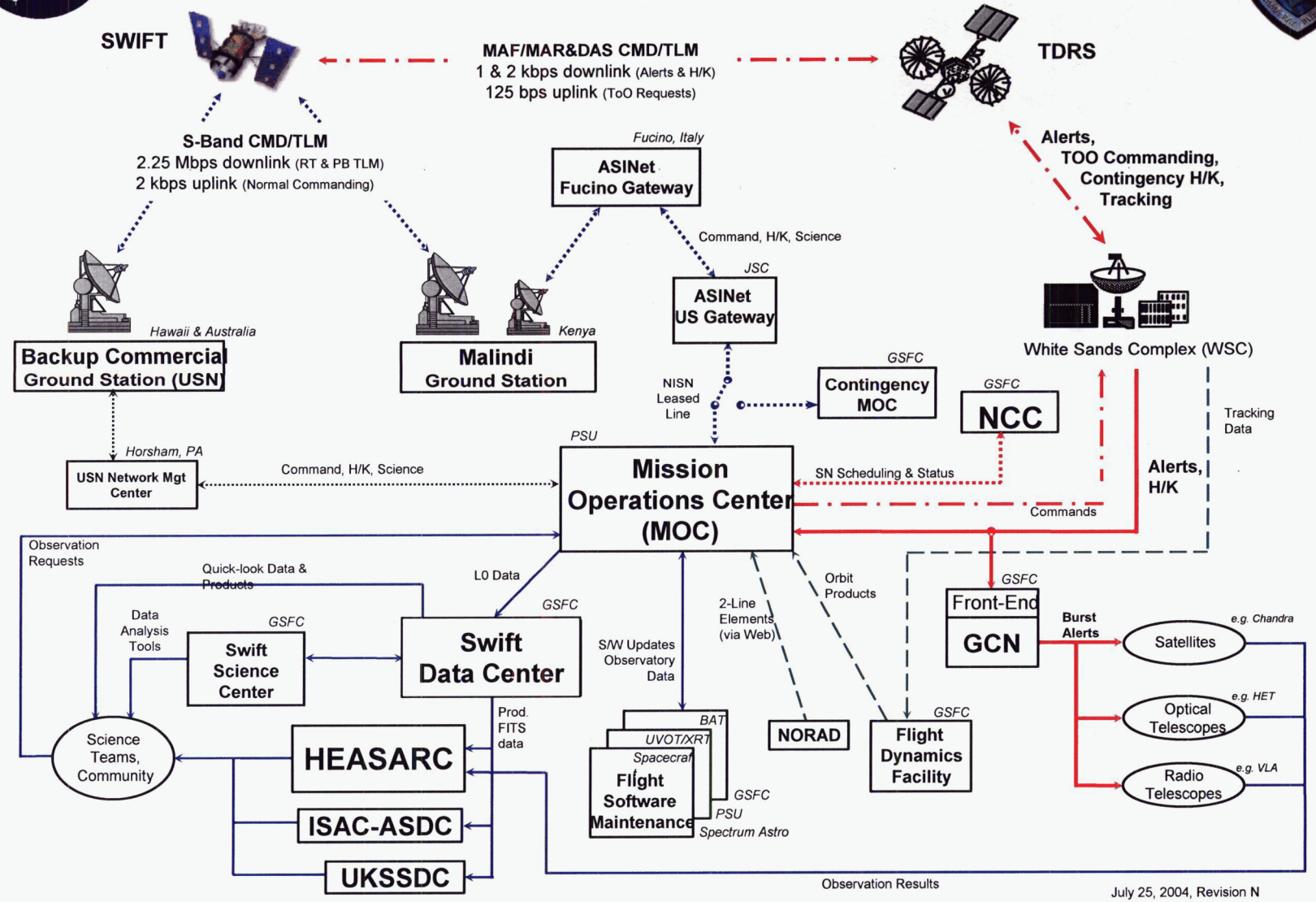


Mission Operations Overview



- Swift Observes Pre-Planned Targets Until Burst Detected Within BAT Field of View
- Swift Rapidly Slews to Point NFIs at Burst and Sends Burst Data to Ground via TDRS Satellites
- Sun, Earth Limb, Moon, and Ram Pointing Constraints Observed to Protect Instruments
- Ground Station in Malindi, Kenya Used for Telemetry and Commanding
- Mission Operations Center Controls Swift Operations

Ground System Architecture



Operations Concept

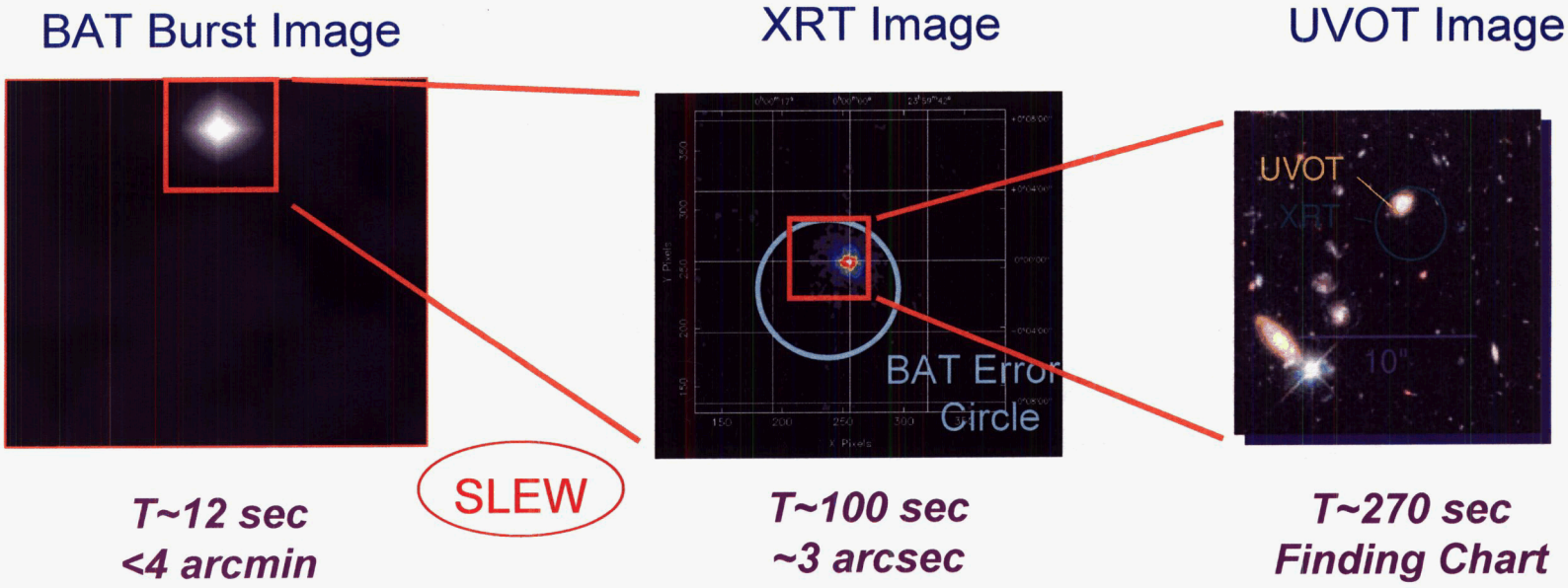
- Highly Autonomous Mission
  - On-board
    - Detect GRBs, Slew & Perform Follow-up Observations with XRT, UVOT
    - Set Correct Instrument Configurations During Observations, Slews & South Atlantic Anomaly (SAA)
    - Allow for at least 72 hours of Autonomous Operations (for unstaffed weekends)
    - On-demand downlink of Science & Anomaly Messages via TDRSS
    - Near-continuous Downlink of Engineering Data via TDRSS
    - Downlink Stored Engineering and Science Data via Malindi
  - Ground
    - Monitoring & Processing of Telemetry from Malindi (7-11 contacts per day)
    - Notify Ops Teams of Bursts, Targets of Opportunity (ToOs) & Anomalies
    - Provide As-flown Timeline of Science Targets Quickly
- Flight Operations Managed At Penn State University (PSU)
  - 8x5 Staffing, with 24x7 Response for ToOs and Anomalies
  - Daily commanding only during staffed hours

Orbit & Operational Constraints

- BAT discovers GRBs using a 60 x 90 degree field of view
- XRT & UVOT identifies afterglows within a 0.5 x 0.5 degree field of view
- Viewing Constraints
  - BAT has a Moon constraint
  - XRT & UVOT have Earth limb, Sun, Moon & RAM observing constraints
  - UVOT has a Bright Object constraint

Onboard GRB Detection & Follow-up

1. BAT Triggers on GRB, Calculates Position on Sky to < 4 Arcmin
2. Spacecraft Autonomously Slews to GRB Position in 20-70 Secs
3. XRT Determines Position to ~3 Arcseconds
4. UVOT Images Field, Transmits Finding Chart to Ground

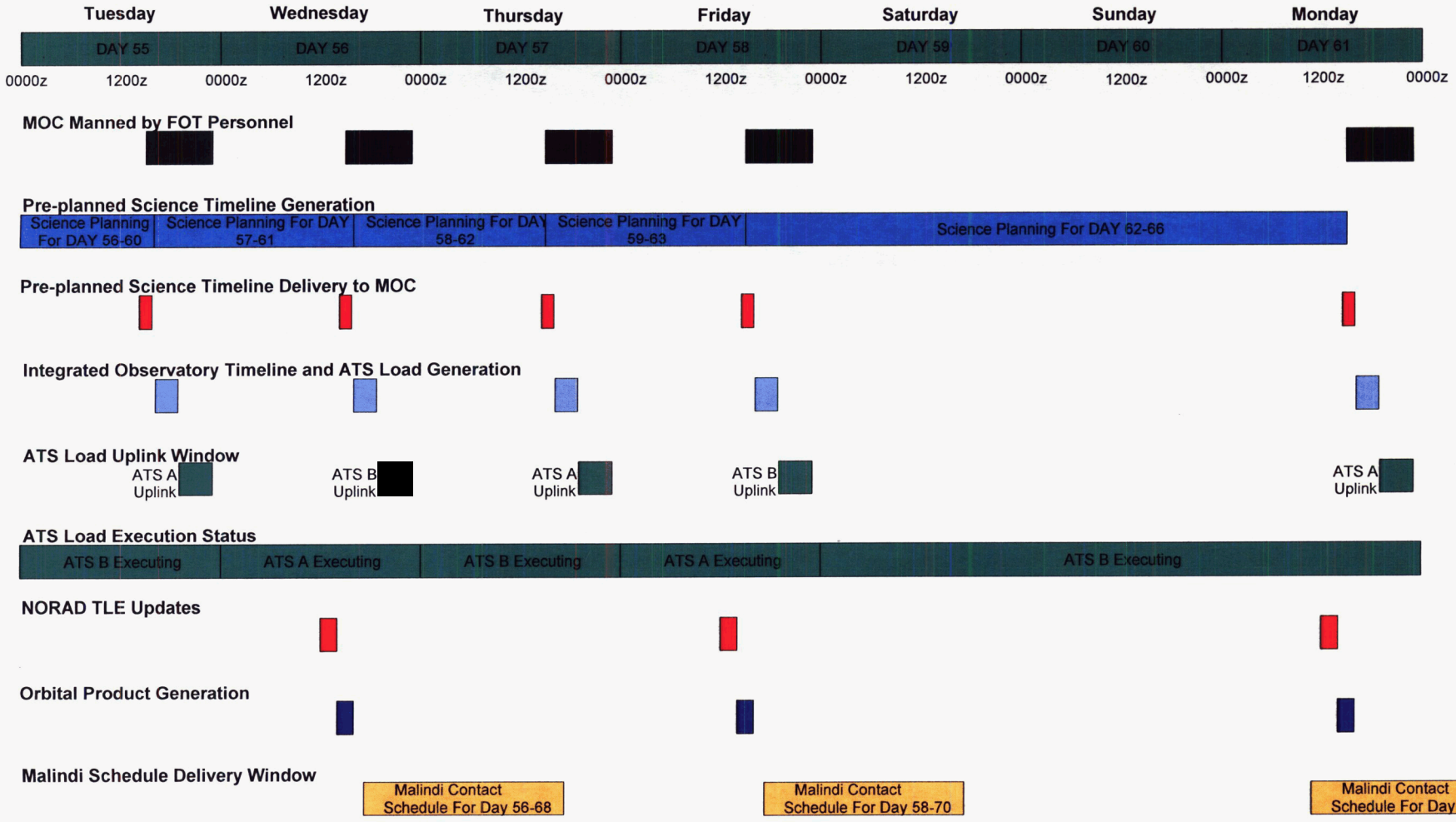


Burst Message Handling

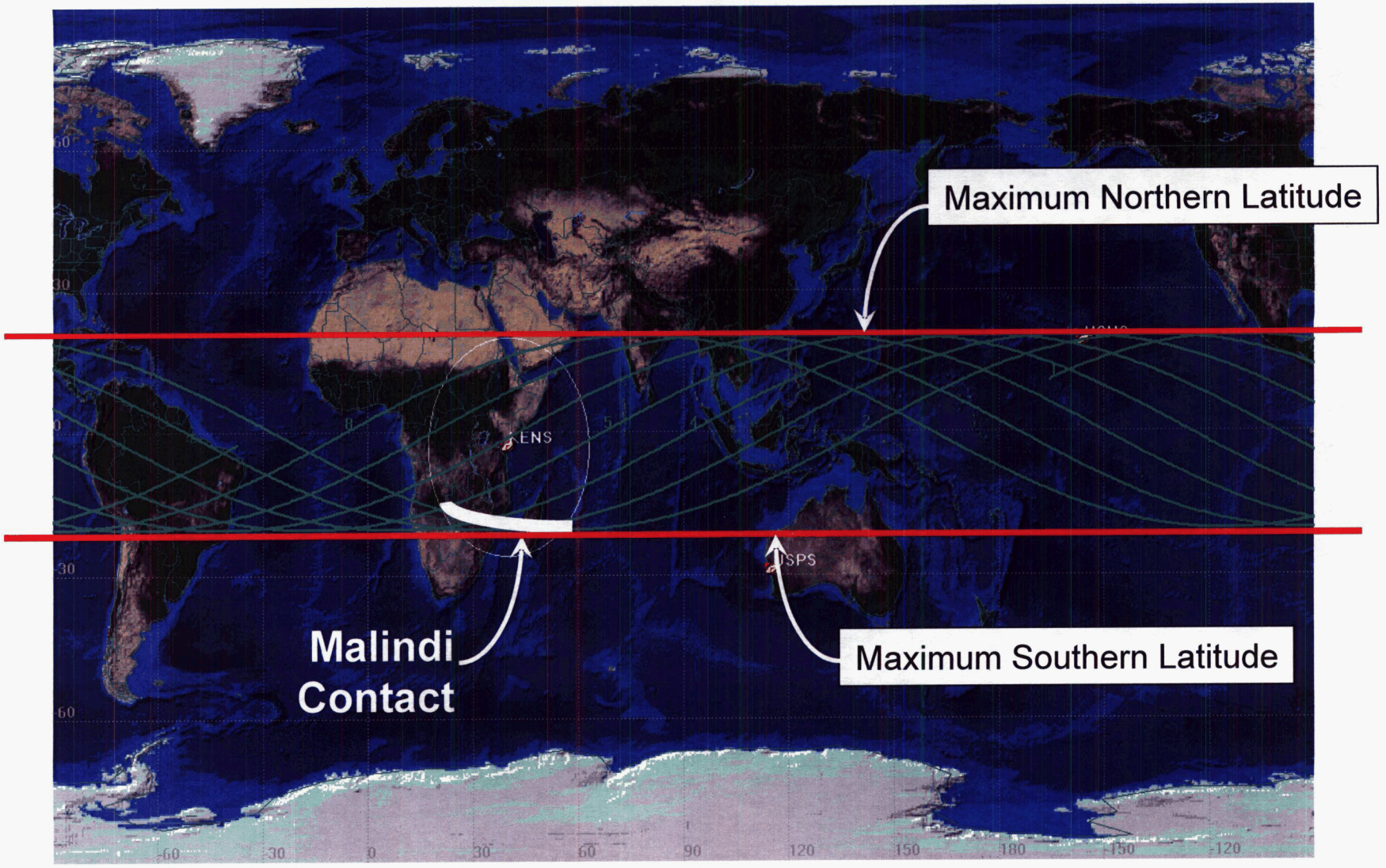
- Burst Alert Messages Downlinked to Ground in Real-Time Via SN/TDRSS Demand Access Service (DAS)
  - DAS Provides Near Continuous Coverage
  - Messages Relayed to GRB Coordinates Network (GCN) for Distribution to the Science Community in Near Real-Time
- GRB Coordinates Network (GCN)
  - Existing System (Since 1992) Used for Distributing GRB Alerts and Initial Results
  - Reformatted Versions of Raw GRB Messages Forwarded to Other Missions and Ground-based Resources, Some Of Which Are Automated, for Potential Follow Up Observations
  - Swift Messages Currently Distributed to Selected Recipients, Wider Distribution Scheduled to Begin Within Next Couple of Weeks
  - Swift "911" Messages Processed As a Back-up to MOC

Mission Planning

"A Week in the Life of Swift"

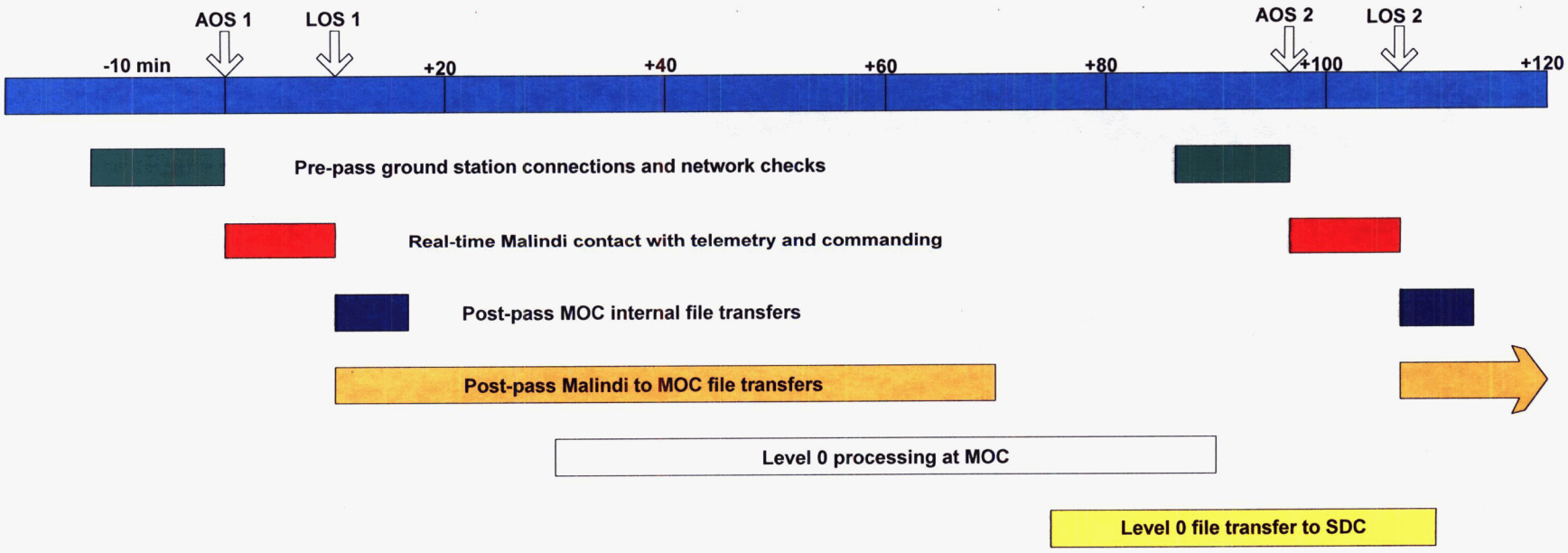


Swift Orbit Trace



Real-time Support

"A Pass in the Life of Swift"



Health & Safety Monitoring

- Evaluate overall Observatory state
  - Real-time:
    - Monitor received State-of-Health telemetry (Ground Network or TDRSS) for out-of-limits
    - Ensure Spacecraft and Instruments in expected configuration
    - Review both S/C and Instrument Event Messages
    - Monitor Solid State Recorder performance
    - Verify Pre-Planned Science Timeline is executing properly
  - Offline:
    - Recorded State-of-Health telemetry automatically monitored for out-of-limits and configuration violations
    - Analyze Trend Data
    - Review both S/C and Instrument Event Messages

Contingency Operations

- Spacecraft 1st line of defense for observatory anomalies – fault protection/automated response
- FOT provides initial response for spacecraft, instrument, and ground system anomalies
- FOT paged by MOC system for Observatory telemetry violations and instrument alert messages
  - FOT response time is 10 minutes, else page will be escalated
  - FOT personnel can be on-site at the MOC within an hour
- FOT assesses data, logs, and addresses anomaly as appropriate:
  - For pre-defined contingency, exercise contingency procedure
  - Escalation per defined procedure
  - Log anomaly report in SERS

Operations Training

- Training and Certification Plan outlines training activities required to operate mission
- FOT Certification requires:
  - Completion of skills checklist to demonstrate proficiency
  - Certification Test
- Two Levels of Certification
  - Command Control (CC)
    - Requires minimum skills to perform routine real-time and offline operations
    - Passing Score of 90% on multiple choice CC Test
    - Completion of Skills Catalog (including 1 week Performance Evaluation)
  - Spacecraft Analyst (SA)
    - Requires detail knowledge of real-time, offline, and mission planning operations, spacecraft subsystems, and instruments
    - Passing Score of 90% on SA Tests
    - Completion of Skills Catalog (including 1 week Performance Evaluation)

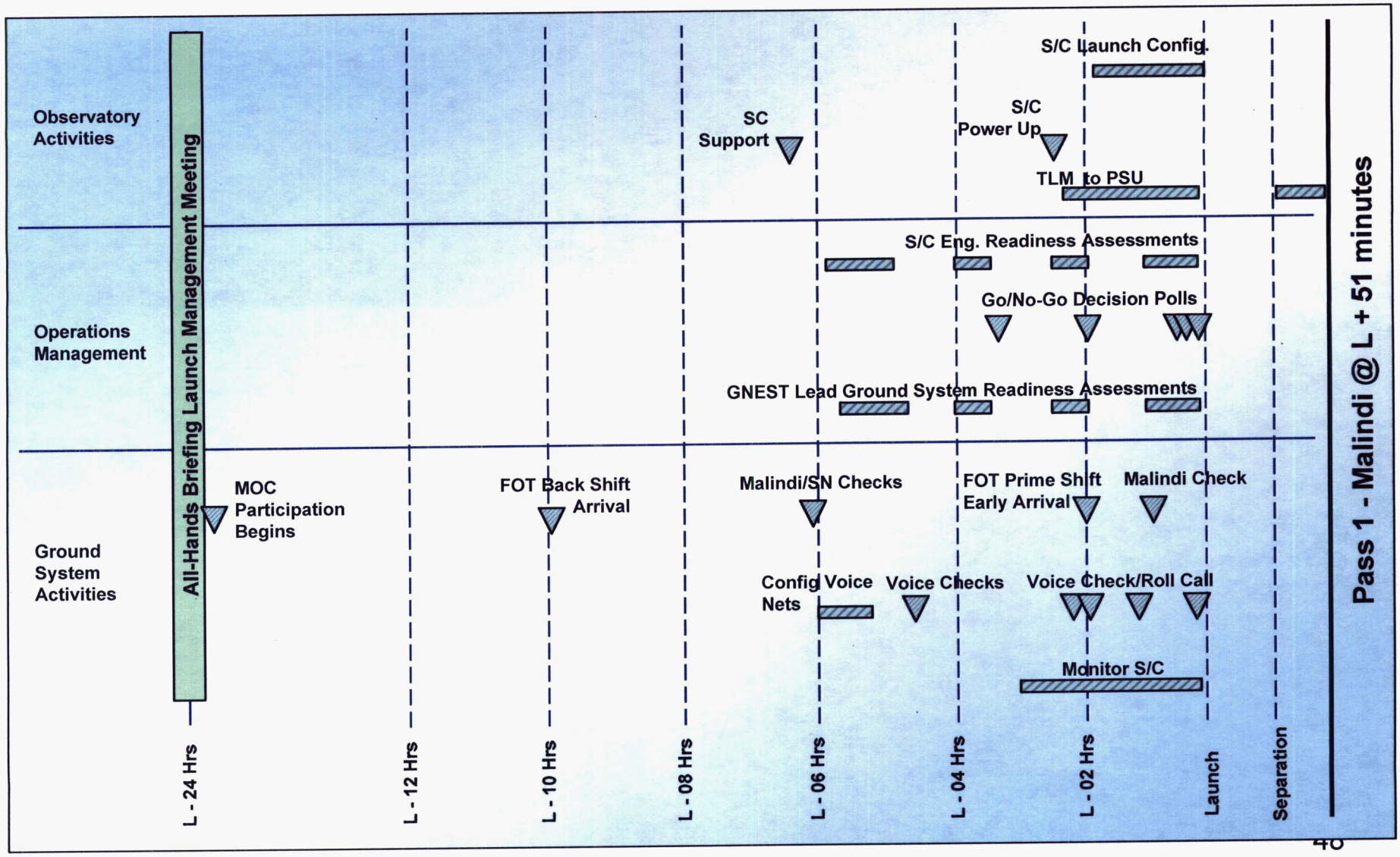
Pre-launch Operations Training

- Classroom Training
  - Spacecraft Bus and Instrument training sessions taught by subsystem engineers
- Procedure walkthroughs
- Ground System Testing
  - Ground Station (Malindi, USN), Space Network (TDRSS), Science Data Center Interface testing
  - Spacecraft Interface Tests (SCIFs) and RF Compatibility tests
  - End-to-End tests using Ground System and Observatory
- Integration & Testing (I&T) Support
  - Participate in functional and environmental testing
- Operational Simulations
  - Launch & Early Orbit, Normal Operations, and Contingency
- Operations Readiness Tests (starting ~3 months before launch)
  - Practice nominal and anomalous Real-time contacts process

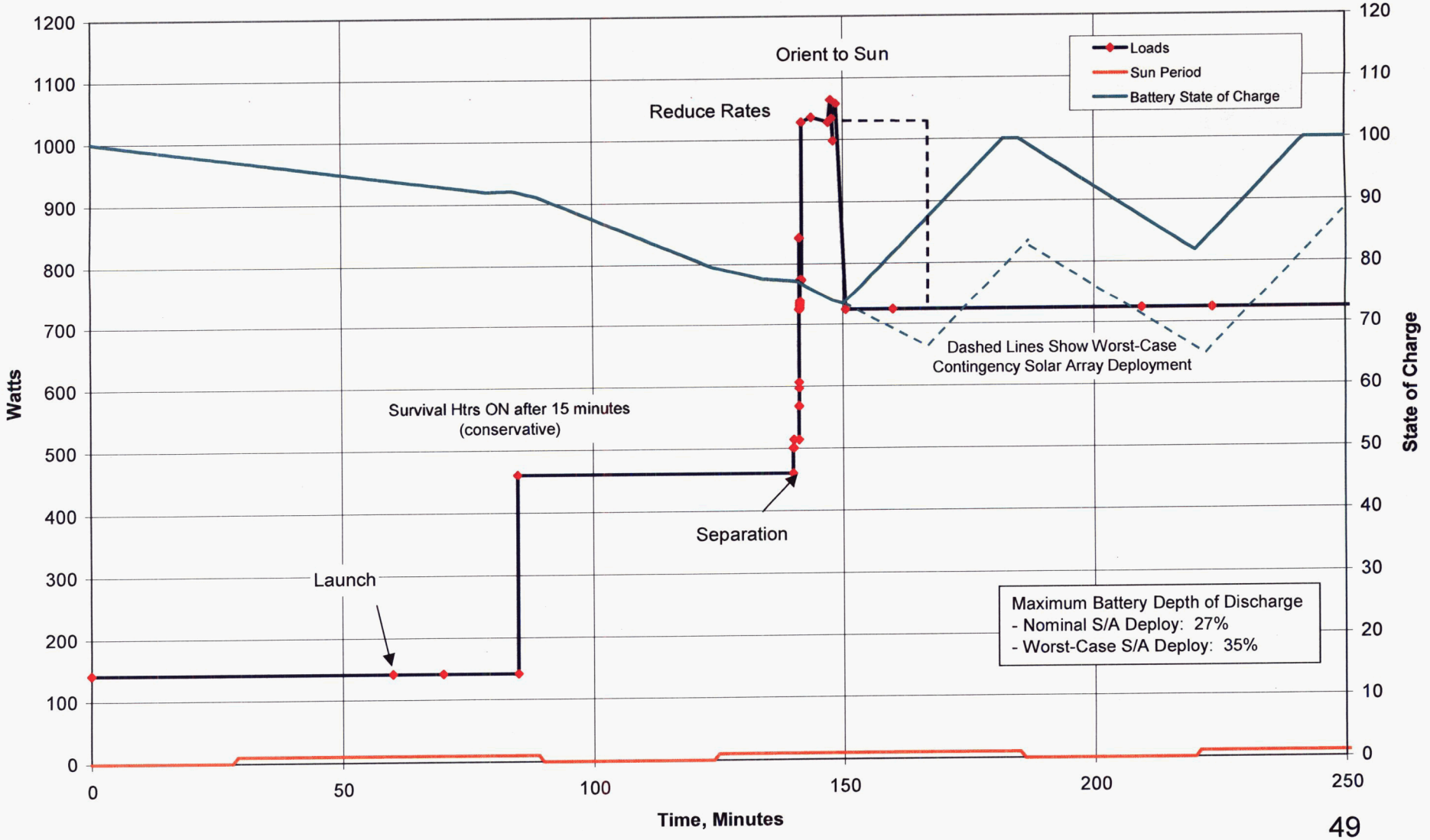
L&EO Objectives

- Successful Launch and Start-up Sequence Executes Properly
- Configure Subsystems for On-orbit Operations
- Spacecraft Bus Checkout and Configuration for Mission Operations
  - Perform Spacecraft Bus Checkout to Verify Subsystem Performance
  - Tweak Subsystem Parameters to Optimize Operations and Support Mission Objectives
  - Power-On and Start Instrument Activation Sequences
  - Verify Spacecraft Bus Functions Support Instrument Operations

Launch Countdown Timeline



Power Profile



Ascent Timeline

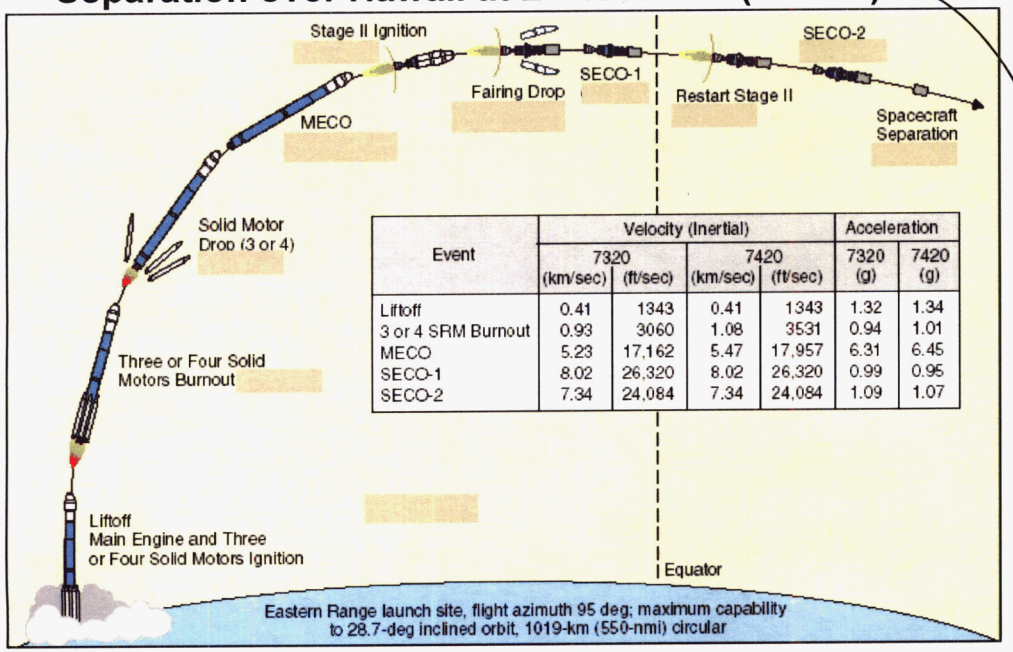
Delta Mission Profile Designed to Minimize Orbit Inclination (~ 20.7°)

- **Low Inclination Improves Instrument Performance by Minimizing Background Radiation**

Delta Performs "Barbeque" Roll During Coast Phase for Swift Thermal Control

Delta Executes 3 Burns during Ascent

Separation over Hawaii at L+ 4800 sec (80 min)



Event	Velocity (Inertial)				Acceleration	
	7320		7420		7320	7420
	(km/sec)	(ft/sec)	(km/sec)	(ft/sec)	(g)	(g)
Liftoff	0.41	1343	0.41	1343	1.32	1.34
3 or 4 SRM Burnout	0.93	3060	1.08	3531	0.94	1.01
MECO	5.23	17,162	5.47	17,957	6.31	6.45
SECO-1	8.02	26,320	8.02	26,320	0.99	0.95
SECO-2	7.34	24,084	7.34	24,084	1.09	1.07

Time (s)	EVENT
0.000	STAGE I LIFTOFF
30.091	MACH NUMBER = 1
44.623	MAXIMUM DYNAMIC PRESSURE
63.120	GROUND LIT SOLID MOTORS BURNOUT
67.000	JETTISON 4 GROUND LIT SOLID MOTOR CASINGS
70.000	BEGIN STAGE I ROLL PROGRAM
264.040	MAIN ENGINE CUTOFF
270.040	VERNIER ENGINE CUTOFF
272.040	STAGE I-II SEPARATION
277.540	STAGE II IGNITION SIGNAL
277.940	START OF STAGE II STEADY STATE
282.000	JETTISON FAIRING
590.641	FINAL INSTANTANEOUS IMPACT POINT
595.929	ENGINE CUT OFF COMMAND / END STAGE II PITCH PROGRAM
596.217	FIRST CUTOFF - STAGE II (SECO 1)
650.000	BEGIN COAST PHASE ROLL PROGRAM
1644.957	FIRST RESTART - STAGE II
1645.357	START OF STAGE II STEADY STATE
1684.361	ENGINE CUT OFF COMMAND
1684.634	SECOND CUTOFF - STAGE II (SECO 2)
1975.000	BEGIN FOURTH ROLL RATE - COAST PHASE (BEGIN BBQ)
3777.000	END FIFTH ROLL RATE - COAST PHASE (END BBQ)
4098.413	SECOND RESTART - STAGE II
4098.813	START OF STAGE II STEADY STATE
4161.304	ENGINE CUT OFF COMMAND
4161.603	THIRD CUTOFF - STAGE II (SECO 3)
4770.000	FIRE SEPARATION BOLTS
4800.000	SPACECRAFT SEPARATION (REL LATCHES)
4800.500	BEGIN STAGE II RETRO
4842.000	END STAGE II RETRO
5200.000	BEGIN COLD GAS EVASIVE MANEUVER
5230.000	END COLD GAS EVASIVE MANEUVER
6150.000	THIRD RESTART - STAGE II
6150.400	START OF STAGE II STEADY STATE
6159.330	FOURTH CUTOFF - STAGE II (SECO 4)

SWIFT Launch

- Launch and Fairing Ejection